# Center for 'NANOSIZE INORGANIC MATERIAL POWDERS BY MOLECULAR DECOMPOSITION'

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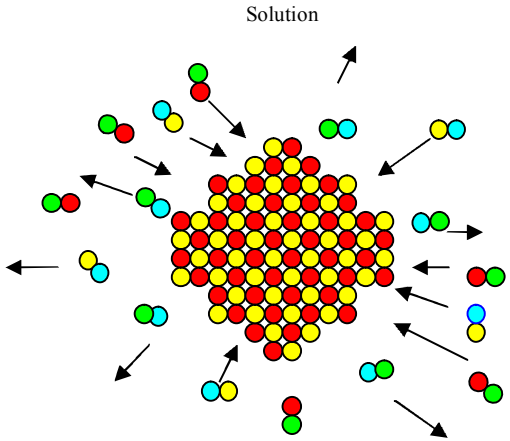
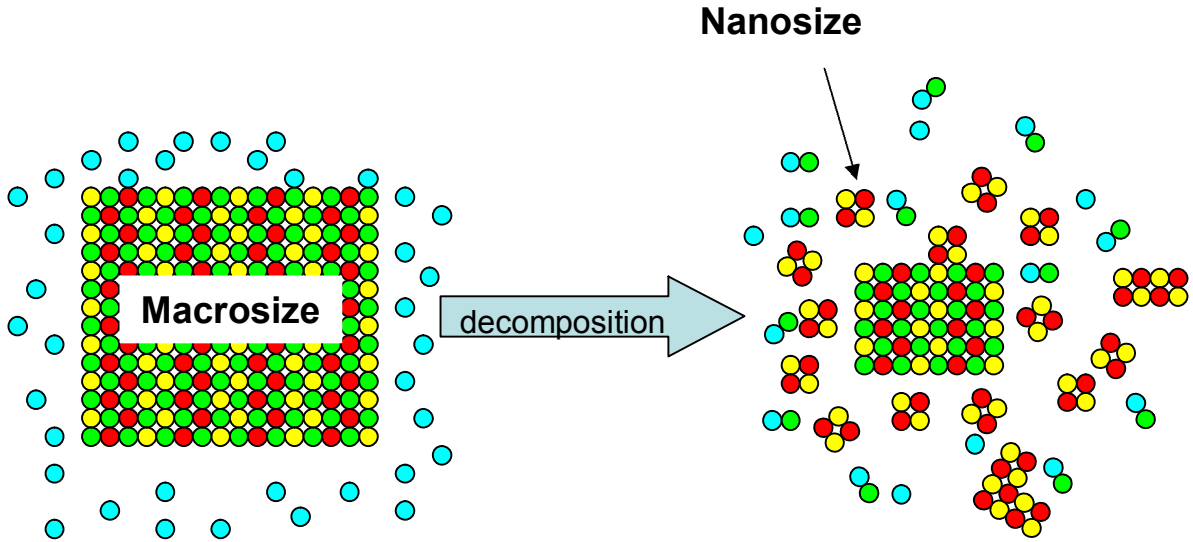
Center Proposal Presentation
May 10, 2005

# Center Technology: Center Materials (MD)




**Conventional:**
**Molecular Synthesis**

Atom by Atom Addition




**Center Technology:**
**Molecular Decomposition (MD)**

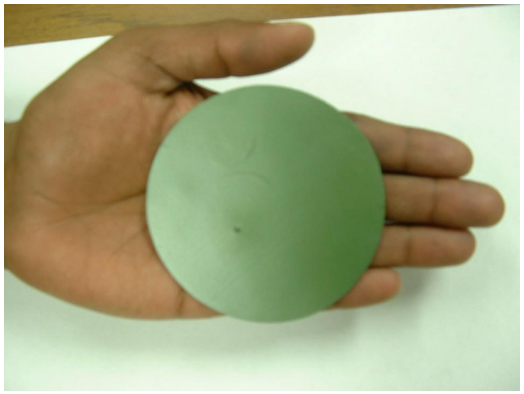
Chemically Break a Molecule

Benefits of the MD Process

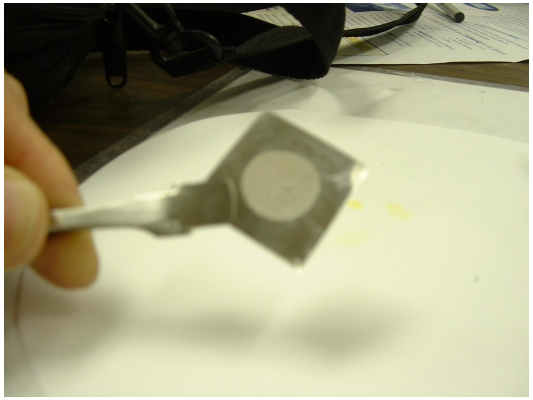
1) Low cost
2) Uniform, nanosize
3) Various Compositions
4) Not restricted to powders

# Center Products

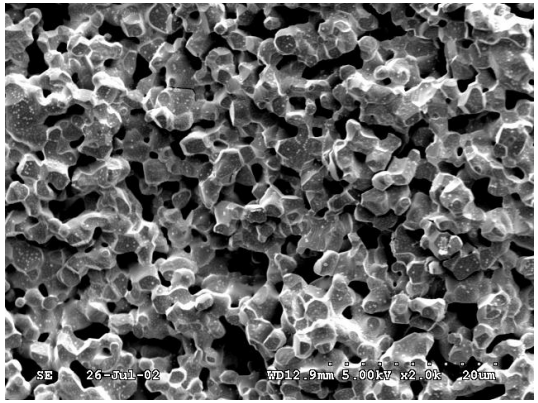
## Made Using Nanosize MD Process



**Fuel Cell**

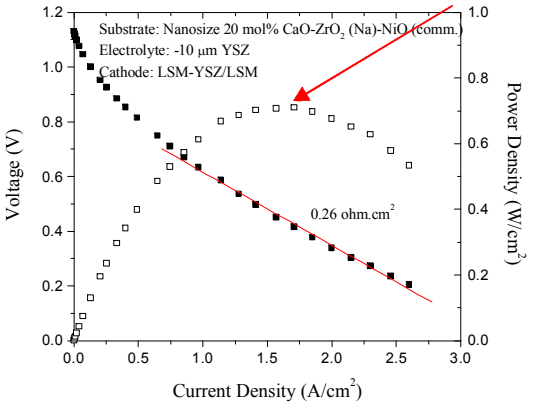


**Membrane**



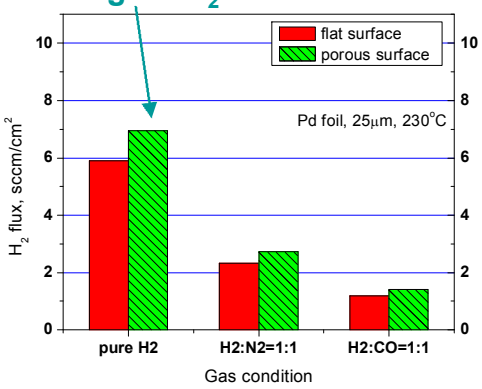

**Sensor Microstructure**

**Excellent Power = 0.7 W/cm²**




**Fuel Cell Performance**

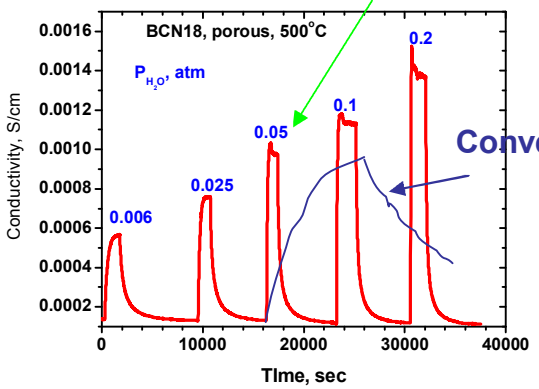
**Higher $H_2$ Flux**




**Hydrogen Permeation**

**Fast Response**

**Conventional**




**Sensor Response**

# IP Status

## 2 Patents Issued, 1 filed, 2 in preparation

| Technology Description | Patent, ID# or Application # | Date |
|---|---|---|
| Australian patent on Nanosize Powders: | AU758256 | Issued 8-30-2004. |
| U. S. Patent on Nanosize Powders | US6803027 | Issued 10-12-2004 |
| U. S. Patent Application on Nanosize Powders | U. S. Patent Application Doc. No.23347. PCT.US.CIP | Filed 12-2004 |
| U. S. Patent Application in preparation: Nanostructured Membranes | In preparation | |
| Invention Disclosure 'Proton Conductor-Based Humidity Sensor' | U-3575: Application planned | |

# Product Category Options

- Nanopowders – Components (Cutting tools, wear parts, valve seats, fuel cells, etc.)
- Nanocatalysts – Chemical Processes (Fuel reforming, chemical synthesis, catalytic converter, etc.)
- Nanostructured Sensors – Many Applications (Environment control, chemical industry, medical, etc.)
- Nanostructured Membranes – Gas Separation (Hydrogen separation, liquid separation, etc.)

# Technology Features: Powders

| Center Technology | Technology Features | Technology Advantages |
|---|---|---|
| Catalyst Powders | -Uniform, nanosize (3-5 nm),<br>-high surface area,<br>-composition control | -Crystalline,<br>-uniform properties,<br>-low cost |
| Ceramic powders | -Supplied dry or liquid suspensions | -Crystalline powders ready to use |

# Technology Features: Membranes

| Center Technology | Technology Features | Technology Advantages |
|---|---|---|
| Fuel Cells | Inexpensive powders | -Low-cost,<br>-Energy efficient process |
| Membrane Separation | Catalytic membranes | Highly permeable hydrogen separation membranes |

# Technology Features: Sensors-Filters

| Center Technology | Technology Features | Technology Advantages |
|---|---|---|
| Sensors | -Nanoporous,<br>-Fast response | -Rugged,<br>-inexpensive |
| Filters | Nanoporous filters for gases and liquids | -Controlled porosity<br>-Rugged<br>-Corrosion-resistant |

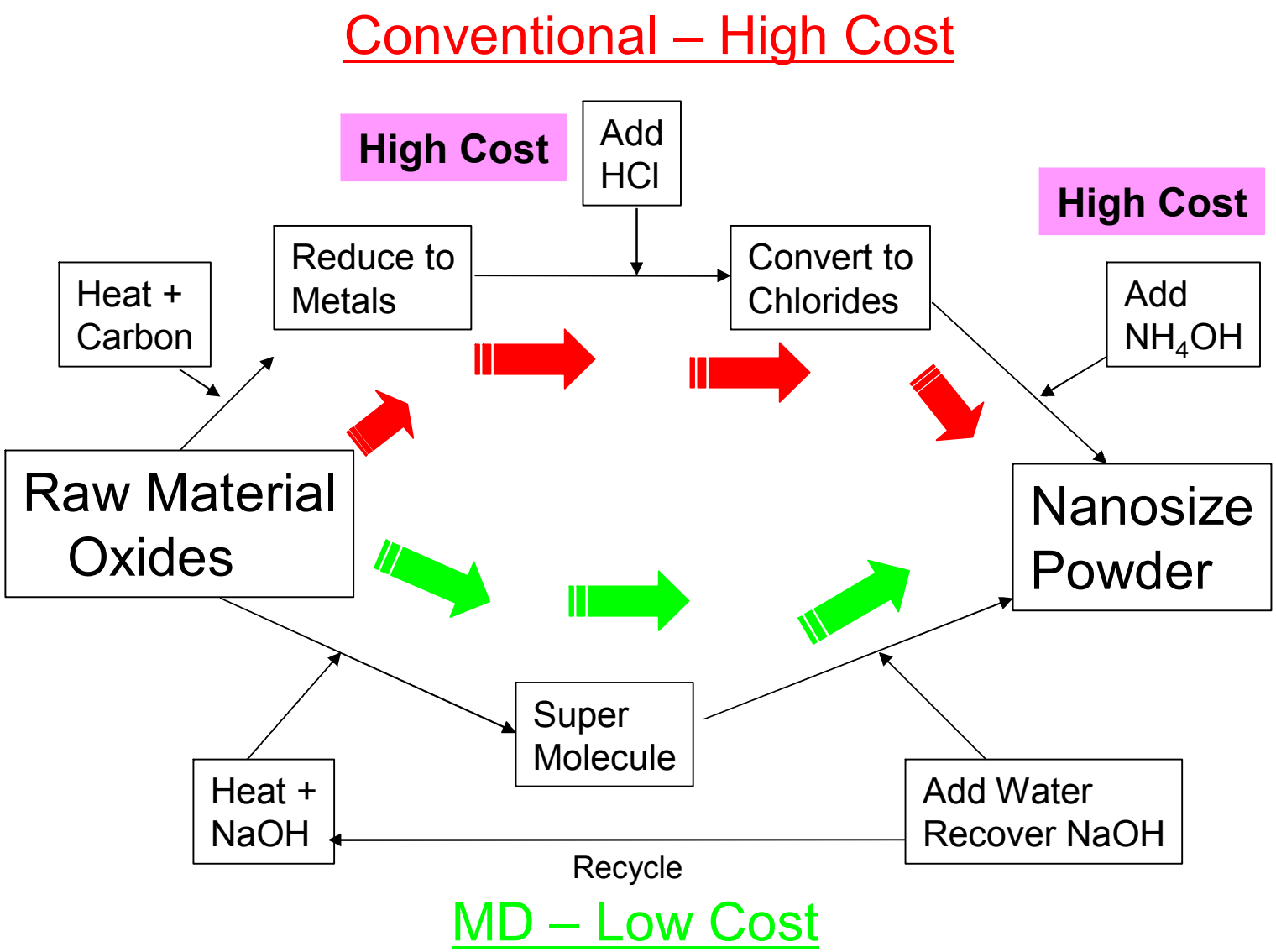
# Product Feature and Competitive Analysis with Competitors

| Product Feature | University of Utah Center Product | Nanophase Technologies Corporation | Applied NanoWorks Inc. | Altair Nano Materials Inc. | Integran Technologies Inc. |
|---|---|---|---|---|---|
| High surface area powders | **Yes** | Yes | Yes | No | Yes |
| Nano size crystallites | **Yes** | Yes | Yes | No | Yes |
| Low-cost Raw Materials | **Yes** | No | No | No | No |
| Low-cost equipment | **Yes** | No | Yes | No | No |
| Powders: dry or liquid suspensions | **Yes** | Yes | No | No | Yes |
| Nanostructured surface layers | **Yes** | No | No | No | Yes |
| Nanoporous sensors | **Yes** | No | No | No | No |

# Cost Comparison for n-YSZ: Center Technology vs. Commercial Powders

| Name of the Vendor | Trademark for 8YSZ | Quoted price per kg for 30 kg | Quoted price per kg for 100 kg |
|---|---|---|---|
| Center Technology | High Margins!! | Mkt. Flexibility | $15.00 (est.) |
| American Vermiculite | HSY-8.0 | $77.00 | $77.00 |
| Fuel Cell Materials Division of NexTech | YSZ8-CT | $114.00 | $108.00 |
| Tosoh USA, Inc. | TZ-8Y | $127.00 | $118.0 |
| Praxair Surface Tech. Specialty Ceramics Not Nanosize | | $50.00 | $30.00 |

# Why the Center Technology is Low Cost?



# First Year Milestones Accomplished

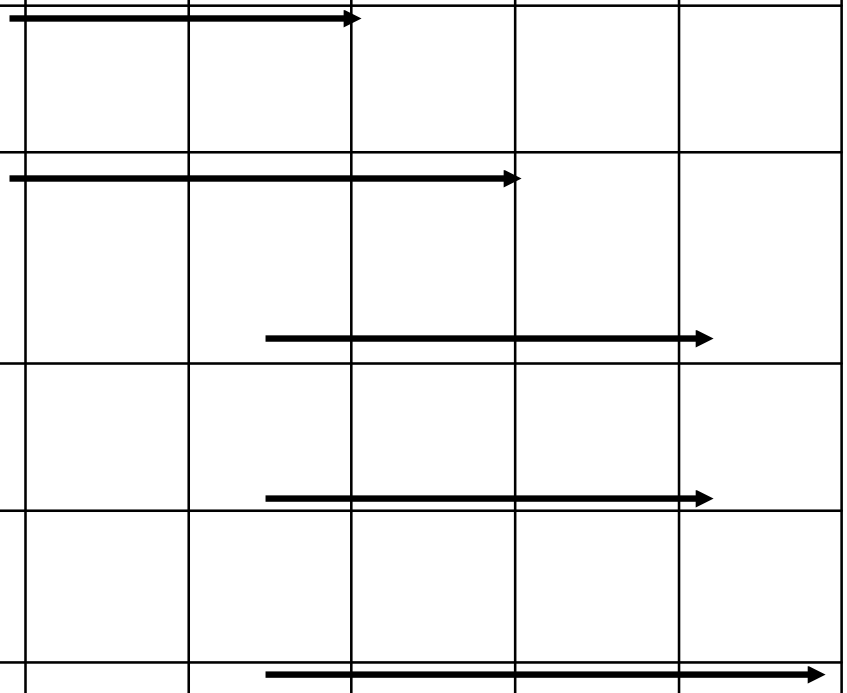
| Milestones | Date |
|---|---|
| •Intellectual Property: Two patents issued | October 2004 |
| •Nanosize metal powders demonstrated | November 2004 |
| •Patent on metal powders filed | December 2004 |
| •Nanosize powders for fuel cells, capacitors, structural ceramics | January 2005 |
| •Commercialization consultant on board | January 2005 |
| •Membranes demonstrated | January 2005 |
| •Lab scale reactor for MD process | April 2005<br>Parts ordered |

# Technology Status – Product Oriented

| Product | Bench Tested | First Product Anticipated Date |
|---|---|---|
| Nanosize Powders | Yes | 4th Quarter 2006 |
| Catalysts | Yes | 4th Quarter 2007 |
| Membranes | Yes | 4th Quarter 2008 |
| Filters | No | 4th Quarter 2008 |
| Sensors | Yes | 4th Quarter 2009 |

# Technology Development Milestones

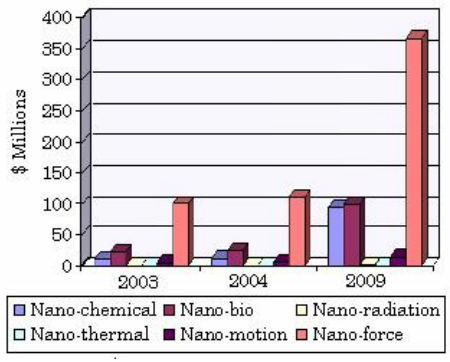
| Milestone/Technology Development | Year 1 04-05 | Year 2 05-06 | Year 3 06-07 | Year 4 07-08 | Year 5 08-09 |
|---|---|---|---|---|---|
| Nanosize powders for fuel cells: New Utah Company-1 | | | | | |
| Nanosize catalysts for fuel processing: New Utah Company-1 | | | | | |
| Nanostructured separation membranes: License technology | | | | | |
| Nanoporous filters: License technology | | | | | |
| Nanoporous sensors: New Utah Company-2 | | | | | |



# Market Opportunity Analysis

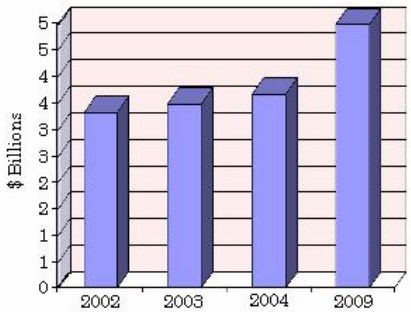
| Market Segment | Price/Unit | Sales Potential in Units | Total Potential Market |
|---|---|---|---|
| **Fuel Cells** | $20/kg | 25 M kg | $500 M |
| **Nanocatalysts** | Material Dependent | Material Dependent | $5 B |
| **Nanosensors** | Sensor Dependent | Sensor Dependent | $500 M |
| **Nanofilms** | Variable | Variable | $1.6 B |
| **Total** | | | **$7.6 B** |

Global Nanosensor Market by Application, 2003-2009 ($ Millions)



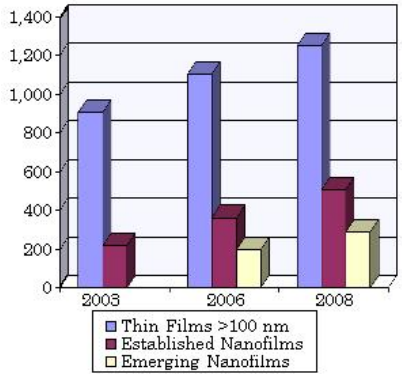

(a)

Global Nanocatalyst Market, 2002-2009 ($ Billions)




(b)

Value of Worldwide Shipments of Thin Films and Nanofilms, 2003-2008 ($ Millions)




(c)

**Source: Business Communications Corporation**

# Business Opportunity

- Multiple License Opportunities
- Two Utah Manufacturing Companies

  (a) Nano powders

  (b) Nano sensors

# Potential Business Partners

- To be identified during the second year.

# PI's Track Record in Starting Business Ventures

- Co-founder of three companies;
  - two in Utah (Ceramatec, Inc. and Materials and Systems Research, Inc., MSRI);
  - one in Illinois (Versa Power Systems, VPS) UURF-equity position.
- ~190 Total employees in three companies
- ~$20M Approximate annual sales

# Current/Pending Support, COE Request

- Annual current funding: ~$1.15 Million (excludes COE)
- Pending: ~$300 k
- Amount of COE 2005-06 request: ~$107 k
- Ratio: ~>10:1